1.1.1.1.1.8 Chapter

9

9. Search Planning and Coverage

This chapter will cover factors that are unique to search and rescue or disaster assessment mission planning. Planning considerations and techniques used in both visual and electronic search missions are included. Most of the planning is done by the incident commander and his staff; however, all crewmembers are expected to understand the planning concepts. Thorough comprehension allows more precise mission performance and increases flexibility, allowing you to effectively deal with changing circumstances.

The discussion that follows, and all future training and actual missions, relies heavily on understanding the "language" of search and rescue. A number of terms and planning factors must be understood when planning and executing search and rescue missions. Here are some important definitions:

Maximum Area of Possibility - This normally circular area is centered at the missing airplane's or search objective's last known position, corrected for the effect of wind. The circle's radius represents the maximum distance a missing aircraft might have flown based on estimated fuel endurance time and corrected for the effects of the wind over that same amount of time. The radius may also represent the maximum distance survivors might have traveled on foot, corrected for environmental or topographical conditions, such as snow, wind, mountains, and rivers.

Probability Area - This is a smaller area within the maximum possibility area, where, in the judgment of the incident commander or planners, there is an increased likelihood of locating the objective aircraft or survivor. Distress signals, sightings, radar track data, and the flight plan are typical factors that help define the probability area's boundaries.

Search Altitude - This is the altitude that the search aircraft flies above the ground.

Track Spacing - The distance between adjacent visual or electronic search flight legs.

Probability of Detection - The likelihood, expressed in a percent, that a search airplane might locate the objective. Probability of detection (POD) can be affected by weather, terrain, vegetation, skill of the search crew, and numerous other factors. When planning search missions, it is obviously more economical and most beneficial to survivors if you select a search altitude and track spacing that increases POD to the maximum, consistent with the flight conditions, team member experience levels, and safety.

9.1 Search Priorities

When faced with a lack of vital information concerning the missing aircraft, mission planners can either give the entire probability area search priority or select a portion of the probability area for a concentrated search. Some of the factors used in estimating the location of the missing aircraft within a portion of the probability area are:

- Areas of thunderstorm activity, severe turbulence, icing and frontal conditions.
- Areas where low clouds or poor visibility may have been encountered.
- Deviations in wind velocities from those forecast by the weather bureau.
- Areas of high ground.
- Any part of the aircraft's track that is not covered by radar.

9.1.1 Search Area Determination

The first task in planning a search and rescue mission is to establish the most probable position of the crash site or survivors. If witnesses or other sources provide reliable information concerning an accident, the location may be established without difficulty. If there is little or no information, the planners face a more difficult task. Regardless of the information available, search planners always prepare a chart to assist in focusing the search and locating the crash site or survivors as quickly as possible.

When defining search area limits, planners first sketch the maximum possibility area. They can focus the initial search in the most likely area and can use the charted area to help screen sightings and other reports. Again, the area is roughly circular, centered on the last known position of the missing aircraft. The radius approximates the distance the objective aircraft might have traveled, given the amount of fuel believed aboard at its last known position, and the wind

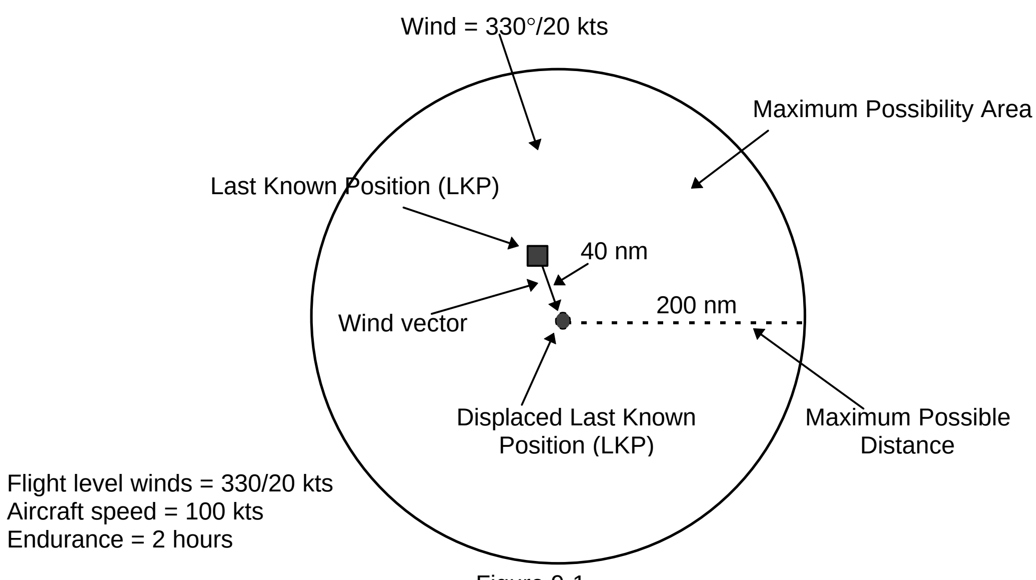

Figure 9-1

direction and speed. The area is circular because it's always possible the missing pilot may have changed directions following his last known position and flown until his fuel was exhausted.

To chart the maximum area of possibility, the planner requires the missing aircraft's last known position, wind direction and velocity, and an estimate of the missing aircraft's fuel endurance and airspeed. Figure 9-1 illustrates the use of these factors to chart the maximum area of possibility. The planner plots the missing aircraft's last known position on a sectional or other chart, then displaces the position for 2 hours of wind effect, or 40 NM, from 330°. From the displaced last known position, he draws a circle with a radius equal to the maximum distance flown by the aircraft. In this case, the planner estimated this range by multiplying aircraft speed, in this case 100 kts, by the estimated endurance of 2 hours.

9.1.2 Probability areas

Plotting the probability area (the area in the possibility circle where the searchers are most likely to find the aircraft) is the second major factor in search planning. The probability area is determined by the accuracy of the LKP in the possibility circle. Primary factors which contribute to the accuracy of the LKP are:

- The aircraft disappearance point on radar.
- The bearing or fix provided by other ground stations.
- Dead reckoning position based on the time of LKP.
- Reports of sightings-either ground or air.
- Emergency locator transmitter (ELT) reports.

There are instances where the above information is not available to assist the search planner. To establish a probable position in these instances, the search planner must rely on less specific secondary sources of information including:

- Flight plan.
- Weather information along the intended route or track.
- Proximity of airfields along route.
- Aircraft performance.
- Pilot's previous flying record.
- Radar coverage along the intended track.
- Nature of terrain along the intended track.
- Position and ground reports.

Based on experience and simulation provided by these factors, the search planner is able to define an area of highest priority to initiate the search. The first search area may be called probability area one. This area begins around the last known position, extends along the intended route and ends around the intended destination. If a search of probability area one produces negative results, the search may be expanded to cover probability area two, an extension of area one.

Organization is an important element in search planning. The time it takes to locate downed aircraft or survivors could depend on the definition and charting of the search area. As an observer, you should become familiar with each designated search area before the mission is launched. You should use current charts and maps which will enable you to provide additional navigational

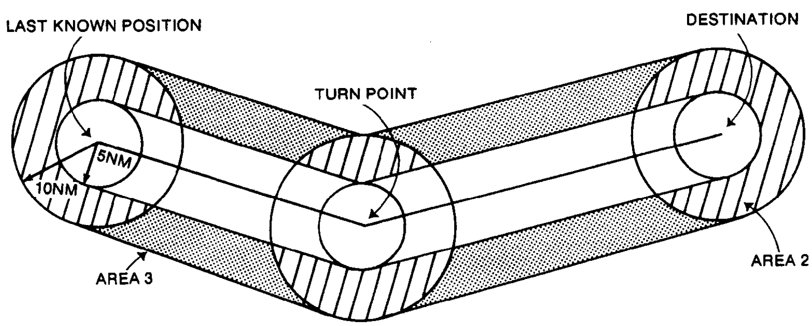

Figure 9-2

assistance in accurately positioning the search aircraft over the properly designated area.

Outlining the maximum area of possibility establishes an *initial* likely area where the missing aircraft might be located. In the earlier example, the maximum possibility area included over 120,000 square miles. The extensive size of the maximum possibility area makes systematic search neither efficient nor practical. It is essential that the planner further focus her search assets and attempt to further define the possible location area. To do this, the search planner charts a *probability area* within the possibility circle.

The probability area is determined by considering other factors that will help to reduce the area of intended search. These additional factors may include:

- Bearing or fix provided by other, non-radar, ground stations.
- Point where the aircraft disappeared from air traffic control radar.
- Dead reckoning position based on time of last known position.
- Reported sightings from either ground or air.
- SARSAT or emergency locator transmitter reports.
- Missing aircraft's flight plan.
- Weather information along the missing aircraft's intended route.
- Proximity of airfields along that route.
- Aircraft performance.
- Missing pilot's previous flying experience and habits.
- Radar coverage along the intended track.
- Nature of the terrain along the intended route.
- Position and ground reports.

In instances when little information is available to assist the planner, he or she reconstructs the incident flight with whatever information may be available. With no information, the search plan is based on an assumption that the missing aircraft is probably located along or near its intended course. The search is initially confined to an area five miles on either side of the intended course, beginning at the last known position and continuing to the intended destination. This first search area is called *probability area one.* The unshaded area in Figure 9-2 represents probability area one.

If search of probability area one produces no results, the search expands to include the area within a ten-mile radius of the last known position, destination, and intermediate points. This area is known as *probability area two* and is depicted by the hatched areas in Figure 9-2.

If the search still produces no results, a third search area is created. *Probability area three* includes areas ten miles either side of the missing aircraft's intended course, excluding those areas already searched in areas 1 and 2. Shaded areas in Figure 9-2 illustrate probability area three. If there is still no result, the incident commander may chart a new probability area within the possibility circle.

When other information *is* available that indicates any of the following factors may have been involved, the incident commander may also consider these factors when assigning priority to initial search areas:

- Areas of thunderstorm activity, severe turbulence, icing, frontal conditions, or any other weather condition that may have influenced a pilot to consider alternate routes to the destination.
- Areas where low clouds or poor visibility might have been encountered.
- Areas of high terrain or mountain passes.
- Any part of the aircraft's course is not covered by radar.
- Reports of ground sightings or of sound from low-flying aircraft.
- Point of last reported radio contact or MAYDAY broadcast.
- Deviations in wind velocities from those forecast.
- Survival factors.

In many military incidents, crewmembers of aircraft may eject or "bail out" of an aircraft prior to its collision with the ground. This is rare in civilian accidents, but if appropriate in either case, planners may also consider parachute drift factors when determining search areas.

9.1.3 Search Altitudes and Airspeeds

Once probability areas are identified, mission planners must make a number of choices as to the size and type of search patterns to be flown, search altitudes, and airspeeds. To make effective choices, the planner first considers factors beyond his or her control, including the size of the search objective, visibility, weather, and sea or terrain conditions.

The size of the search objective, weather, visibility, and ground cover in the search area must be considered when determining the altitude for a visual search. Over non-mountainous terrain, a search altitude between 1000 and 1500 feet above the terrain is normally used for a visual search. The search visibility and the terrain conditions may affect this selection. As altitude decreases below 500 feet, search effectiveness may actually decrease, due to the "rush effect" of objects on the ground passing through the scanner's field of view more rapidly.

Over mountainous terrain, the search altitude may be higher if the planner suspects wind and turbulence near the surface. During darkness, an altitude 3,000 feet above the terrain is considered adequate. Also, rugged terrain can easily block emergency radio transmissions, so electronic searches over such terrain are normally conducted at considerably higher altitudes than would be used during visual searches.

Depending upon the number of search aircraft available to the incident commander, he may also consider the desired probability of detection when selecting an altitude for the search pattern. Although a probability of detection chart is normally used to estimate POD *after* a search, its use here allows incident commanders to predetermine a mission's chance of success. Here's an example of using desired POD to help select a search altitude.

A red and white Cessna 172 has been reported missing and presumed down in eastern Arkansas, in open flat terrain. At the time of the search, flight visibility is forecast to be greater than ten miles. The incident commander determines, based on available aircraft and crews, that the single probability of detection for this first search must be at least 50%.

The POD chart excerpt in Figure 9-3 shows data for open, flat terrain. Other charts are available for hilly terrain or with moderate ground cover, and very hilly, or heavily covered terrain. To the right in the columns beneath "Search Visibility" you see what are, in this case, the desired probabilities of detection. Using one-mile track spacing, you can see that all three altitudes give at least 50% POD, but a search at 1000 feet above the terrain gives 60%, or 10% *more* POD than does a search at 500 feet. Over open terrain, where flight and search visibilities are not limiting factors, the chart demonstrates that a higher altitude is more likely to yield positive results on a single search. Notice that the highest POD in Figure 9-3, 85% is obtained when flying at 1,000 feet above the ground using a track spacing of 0.5 NM.

If weather or visibility are not limiting factor, why then don't you just always elect to fly *that* track spacing at 1,000 feet, and always try to obtain that highest of probabilities of detection? You should recall, from the earlier maximum probability area, that you start with a very large area, then try to focus your efforts on smaller probability areas within that larger area. If the IC/MC has received a number of leads that have reduced the probable area to a small size, he might task you to fly exactly that track spacing and altitude. If the area is not so small, and you try to fly 0.5 NM track spacing instead of 1.0 spacing, you will obviously take *twice* as long to cover the whole area.

OPEN, FLAT TERRAIN				
SEARCH ALTITUDE (AGL)	SEARCH VISIBILITY			
Track Spacing	1 mi	2 mi	3 mi	4 mi
500 Feet				
0.5 NM	35%	60%	75%	75%
1.0	20	35	50	**50**
1.5	15	25	35	40
2.0	10	20	30	30
700 Feet				
0.5 NM	40%	60%	75%	80%
1.0	20	35	50	55
1.5	15	25	40	40
2.0	10	20	30	35
1,000 Feet				
0.5 NM	40%	65%	80%	85%
1.0	25	40	55	**60**
1.5	15	30	40	45
2.0	15	20	30	35

Figure 9-3

The IC/MC also has another option -- he may use to increase the POD. Given adequate resources of aircraft and crews, he can significantly increase the POD by directing multiple searches of the same area, and increasing the amount of time that search forces cover the probability area. This can be demonstrated by using a cumulative POD chart, shown in Figure 9-4, and the earlier example of the missing red and white Cessna. The single-search POD for this hypothetical search was 60%. That mission was flown at 1,000 feet and 1.0 NM track spacing. If you, or another aircraft and crew, fly the same pattern a second time, the POD increases significantly. If the same search is flown again, with the exact same parameters for altitude and track spacing, the overall probability of detection, where the initial 60% intersects the subsequent same single POD, also 60%, is now 80% cumulative. A third search of the same area, again using the same parameters, brings the cumulative POD up to 90%. Since the cumulative POD increases with time in the search area, the incident commander has another option he can select to maximize search coverage.

9.1.4 Executing Search Patterns

The IC/MC and her staff take into consideration many variables including weather, visibility, aircraft speed, aircraft and crew resource availability, crew experience, and the urgency of the situation when developing the search plan. This section covered a number of factors that can affect the choice for search altitudes and track spacing. Similarly, mission planners consider many variables when selecting the search pattern or patterns to be used. Individual search patterns are covered in chapters that follow. All questions about how the search is to be conducted must be resolved at the mission briefing. When airborne, crews must focus on executing the briefed plan instead of second-guessing the planners and improvising.

9.1.5 Search Coverage Probability of Detection

Before a search mission gets airborne, each aircrew has a good idea of how much effort will be required to locate the search objective if it is in the assigned search area. This effort, expressed as a percentage, is the probability of detection, or POD. As a scanner/observer, you may be required to establish a POD for your aircrew's next sortie.

The following terms are associated with determining the probability of detection:

Meteorological visibility - the maximum range at which large objects, such as a mountain, can be seen.

Search visibility - the distance at which an object the size of an automobile on the ground can be seen and recognized from an aircraft in flight. Search visibility is always less than meteorological visibility.

Scanning range - the lateral distance from a scanner's search aircraft to an imaginary line on the ground parallel to the search aircraft's ground track. Within the area formed by the ground track and scanning range, the scanner is expected to have a good chance at spotting the search objective.

Ground track - an imaginary line on the ground which is made by an aircraft's flight path over the ground.

Search track - an imaginary swath across the surface, or ground. Its dimensions are formed by the scanning range and the length of the aircraft's ground track.

Track spacing - the distance between adjacent ground tracks. The idea here is for each search track to either touch or slightly overlap the previous one. It is the pilot's task to navigate so that the aircraft's ground track develops proper track spacing.

Possibility area – the area drawn on a map with its focus at the last known position (LKP) of the missing aircraft. Many factors are considered before establishing a possibility area, but it is the largest geographic area in which the aircraft might be found.

Probability area - the geographic area within which a missing aircraft is most likely to be.

9.2 Probability of detection

A scanner/observer can easily determine a probability of detection (POD) by gathering the data affecting the search and by using a POD chart to calculate the detection probability.

The type of terrain, ground foliage, altitude of the search aircraft, track spacing, and search visibility are vital factors in determining a POD. Once each of these factors is given a description or numerical value, the POD can be determined by comparing the search data with the POD chart data. The following discussion is based on this example search situation:

A Cessna 182, white with red striping along the fuselage and tail, was reported missing in the northwest area of Georgia. The last known position (LKP) of the airplane was 40 miles north of the city of Rome. Geological survey maps indicate that the probability area is very hilly and has dense or heavy tree cover. Current visibility in the area is 3 miles. A search for the airplane and its three occupants is launched using 700 feet AGL for the search altitude and a track spacing of 1.5 miles.

9.2.1 Probability of Detection Table

By referring to a POD chart you will note that there is approximately a 10% chance of locating the missing aircraft during a single search. Locate the numbers in the column describing heavy tree cover and hilly terrain which coincide with the search data mentioned above.

In cases where there are multiple or repeated searches over the same probability area, you should use the cumulative POD chart. This chart is as easy to use as the single search POD chart.

Using the same data that we just mentioned concerning the missing Cessna 182, we can determine the probability of detecting the aircraft during a second search of the probability area. In the first search the POD was ten percent. For the second search (assuming that the data remains the same as was specified for the first search), the POD would be ten percent. However, because this is a repeat, the overall POD increases to 15 percent.

Probably the greatest advantage of using the cumulative POD chart is to indicate to searchers how many times they may have to search a single area to

CUMULATIVE POD CHART

Previous, or Cumulative POD	5-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	80%+
5-10%	15								
11-20%	20	25							
21-30%	30	35	45						
31-40%	40	45	50	60					
41-50%	50	55	60	65	70				
51-60%	60	65	65	70	75	80			
61-70%	70	70	75	80	80	85	90		
71-80%	80	80	80	85	85	90	90	95	
80%+	85	85	90	90	90	95	95	95	95+

POD THIS SEARCH

Figure 9-4

obtain the desired overall POD. For instance, you may want a POD of 80 percent in an area before continuing to another area. If one search of probability area proves futile with a POD of 35 percent and a second search is conducted in the area with a POD of 40 percent, the cumulative POD can be determined easily. The observer in the aircraft would only have to locate the box that intersects the 35 percent POD with the 40 percent POD.

A look at the cumulative POD shows that these two searches would yield a cumulative POD of 60 percent. Therefore, you should search the area again.

Remember, the cumulative POD chart should be used when multiple searches are conducted over the same search area.

This general explanation of the cumulative POD chart has provided some basic information about its use. As a mission observer, you should not primarily concern yourself with extensive calculations involving the cumulative POD. Simply knowing the probability of detection for each mission and the factors contributing to that probability is enough involvement on the mission observer's part. The IC/MC is the primary individual who makes extensive use of the cumulative POD chart.

9.3 Sample Problems for Search Area Planning

Problem #1

Four aircraft have accumulated nine hours over a given search area at an average ground speed of 90 knots. If they used a track spacing (S) of two nm, what is the total area searched in thousands of square miles?

Problem #2

The area to be searched is before sunset is 6000 square nautical miles. With an average ground speed of 60 knots, six hours of good light left in the day, and a track spacing of 1.5 nm, how many aircraft will be required to complete the search?

Problem #3

The area to be searched is 5000 square nautical miles, and the IC/MC has selected two nm track spacing. With three aircraft capable of an average ground speed of 100 knots, how many hours will the search take?